THE ROYAL CANADIAN INSTITUTE

October 1921 Botanical Series Vol. XI, No. 6.

Memoirs of the Department of Agriculture in India

STORAGE

THE INFLUENCE OF ATMOSPHERIC CONDITIONS UPON THE GERMINATION OF INDIAN BARLEY

BY

W. YOUNGMAN, B. Sc

Economic Botanist to Government, United Provinces

LIBRARY MAR 4 - 1953

AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2, Creed Lane, LONDON

Price, As. 9 or 1s.

Digitized by the Internet Archive
in 2008 with funding from
Microsoft Corporation

Edited by
The Council of the Pusa Agricultural Research Institute, which is not, as a body, responsible for the opinions expressed in the Memoir.

http://www.archive.org/details/n06memoirsbotani11impeuoft

October 1921. BOTANICAL SERIES. VOL. XI, No. 6.

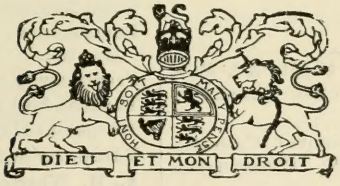
MEMOIRS OF THE DEPARTMENT OF AGRICULTURE IN INDIA

THE INFLUENCE OF ATMOSPHERIC CONDITIONS UPON THE GERMINATION OF INDIAN BARLEY

BY

W. YOUNGMAN, B. Sc

Economic Botanist to Government, United Provinces



AGRICULTURAL RESEARCH INSTITUTE, PUSA

PRINTED AND PUBLISHED FOR

THE IMPERIAL DEPARTMENT OF AGRICULTURE IN INDIA

BY

THACKER, SPINK & CO., CALCUTTA

W. THACKER & CO., 2, CREED LANE, LONDON

Agents for the Sale of Government Publications

IN THE UNITED KINGDOM

Constable & Co., 10, Orange Street, Leicester Square, London, W.C.

Kegan Paul, Trench Trübner & Co., 68-74, Carter Lane, E.C., and 39, New Oxford Street, London, W.C.

Bernard Quaritch, 11, Grafton Street, New Bond Street, London, W.

P. S. King & Sons, 2 and 4, Great Smith Street, Westminster, London, S.W.

H. S. King & Co., 65, Cornhill, E.C., and Pall Mall, London, W.

Grindlay & Co., 54, Parliament Street, London, S.W.

T. Fisher Unwin, Ltd., 1, Adelphi Terrace, London, W.C.

W. Thacker & Co., 2, Creed Lane, London, E.C.

Luzac & Co., 46, Great Russell Street, London, W.C.

Wheldon & Wesley, Ltd., 28, Essex Street, London, W.C.

B. H. Blackwell, 50 and 51, Broad Street, Oxford.

Deighton, Bell & Co., Ltd., Cambridge.

Oliver & Boyd, Tweedale Court, Edinburgh.

E. Ponsonby, Ltd., 116, Grafton Street, Dublin.

ON THE CONTINENT

Ernest Leroux, 28, Rue Bonaparte, Paris.

Martinus Nijhoff, The Hague, Holland.

IN INDIA AND CEYLON

Thacker, Spink & Co., Calcutta and Simla.

W. Newman & Co., Calcutta.

R. Cambray & Co., Calcutta.

S. K. Lahiri & Co., Calcutta.

B. Banerjee & Co., Calcutta.

The Indian School Supply Depôt, 309, Bow Bazar Street, Calcutta, and 226, Nawabpur, Dacca.

Butterworth & Co. (India), Limited, Calcutta.

The Weldon Library, 18-5, Chowringhee Road, Calcutta.

Rai M. C. Sircar Bahadur and Sons, 75-1-1, Harrison Road, Calcutta.

Standard Literature Co., Ltd., Calcutta.

Lal Chand and Sons, Calcutta.

Association Press, Calcutta.

Higginbothams, Ltd., Madras.

V. Kalyanarama Iyer & Co., Madras.

G. A. Natesan & Co., Madras.

S. Murthy & Co., Madras.

Thompson & Co., Madras.

Temple & Co., Madras.

P. R. Rama Iyer & Co., Madras.

Vas & Co., Madras.

E. M. Gopalkrishna Kone, Madras.

Thacker & Co., Ltd., Bombay.

D. B. Taraporevala, Son & Co., Bombay.

Radhabai Atmaram Sagoon, Bombay.

Sunder Pandurang, Bombay.

Gopal Narayan & Co., Bombay.

Ramchandra Govind & Son, Kalbadevi, Bombay.

Proprietor, New Kitabkhana, Poona.

The Standard Bookstall, Karachi.

Mangaldas Harkisandas, Surat.

Karsandas Narandas & Sons, Surat.

A. H. Wheeler & Co., Allahabad, Calcutta and Bombay.

N. B. Mathur, Superintendent, Nazir Kanun-i-Hind Press, Allahabad.

Munshi Seeta Ram, Managing Proprietor, Indian Army Book Depôt, Juhi, Cawnpore.

Rama Krishana and Sons, Lahore.

Rai Sahib M. Gulab Singh & Sons, Mufid-i-Am Press, Lahore.

Superintendent, American Baptist Mission Press, Rangoon.

Manager, the "Hitavada," Nagpur.

S. C. Talukdar, Proprietor, Students and Company, Cooch Behar.

A. M. & J. Ferguson, Colombo, Ceylon.

THE INFLUENCE OF ATMOSPHERIC CONDITIONS UPON THE GERMINATION OF INDIAN BARLEY.

BY

W. YOUNGMAN, B. Sc.,

Economic Botanist to Government, United Provinces.

[Received for publication on 14th May, 1921.]

In 1913 attention was called by the Imperial Institute to the fact that whilst Indian barley proved to be quite satisfactory generally for malting purposes in the United Kingdom yet "other shipments contained a large percentage of grains that would not germinate, sometimes amounting to 10 to 20 per cent." The matter was referred to the Department of Agriculture, United Provinces, by the Imperial Institute, and Mr. Wilson, who was then Assistant Economic Botanist, United Provinces, was instructed to carry out an investigation into the matter. Mr. Wilson had collected much information as to methods of storage, and a large number of germination experiments were performed by him when he was transferred to another province. The information and figures collected by Mr. Wilson later passed into my hands. The investigation was again started by me *de novo*, but I wish to acknowledge that the data collected by Mr. Wilson were of considerable assistance to me in my work. The following observations are the result of this work upon the germination of barley carried on through the two seasons 1919 and 1920.

The Imperial Institute reported that it had been noticed that the early shipments of barley generally germinated well and that it was usually the later shipments which exhibited defect.

The quantity of Indian barley exported during the six years 1913–19 is shown in the following table :—

TABLE I.*

Quantity and value of barley exported during six years with the share of the different ports.

Ports		1913–14	1914–15	1915–16	1916–17	1917–18	1918–19
		Tons	Tons	Tons	Tons	Tons	Tons
Karachi		127,622	28,865	159,533	172,034	347,747	215,305
Calcutta		54,249	54	74	1,478	97	43
Bombay		8,519	394	6,147	35,929	10,787	10,999
Rangoon		10	4	3	5	91	4
TOTAL	Quantity	190,400	29,317	165,757	209,416	358,722	226,351
	Value £	1,043,799	174,548	1,168,003	1,509,615	2,693,512	1,845,111

* This statement is taken from the " Handbook of Commercial Information for India," by C. W. E. Cotton, 1919.

Export figures obtained from the Director of Statistics with the Government of India showed the exports of barley by sea to foreign countries month by month for the year 1913-14 to be as under :—

TABLE II.

Quantity of barley exported by sea from each maritime province of British India to foreign countries in each month of the official year 1913-14.

Months	Bengal	Bombay	Sind	Madras	Burma	Total
1913	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.	Cwt.
April	12,864	18,885	9,682	..	54	41,485
May	101,758	4,176	236,862	..	12	342,808
June	276,564	12,782	199,919	..	30	489,295
July	201,569	46,167	819,373	..	..	1,067,109
August	228,761	40,293	526,415	..	..	795,469
September	125,265	28,009	309,454	..	..	462,728
October	44,153	14,134	197,432	..	..	255,719
November	85,851	2,644	146,055	..	..	234,550
December	8,034	1,456	17,599	..	..	27,089
1914						
January	30	1,438	60,254	..	34	61,756
February	108	82	3,444	..	10	3,644
March	40	318	25,946	..	50	26,354
TOTAL	1,084,997	170,384	2,552,435	..	190	3,808,006

The year 1913-14 is perhaps the fairest average year to take for indication as to the movement of the grain for two reasons—it represents a year uninfluenced by war, and we may assume that the barley was more likely to be wanted for malting purposes then than in later years when there were restrictions as to brewing and greater demand for barley for both human and cattle food. For the latter purpose be the germination bad or good it is immaterial.

The statistics show plainly that much the greatest amount is exported in the month of July. Indeed in this month alone normally some one-third of the total yearly export leaves our Indian ports. This is no doubt the climax of an attempt on the part of the exporter to avoid the monsoon.

Practically the whole of the exports go to the United Kingdom. Particular attention may be called to the large amount that is moved toward Calcutta (Bengal, in Table II) for export in the months of June, July, August, and September. As we shall show later, the region of Bengal and the Bay of Bengal during these months is a danger zone for barley. Barley subjected for some 3–4 weeks to the conditions prevailing in this region is bound to have its germination percentage considerably reduced.

The explanation of the poor germination suggested by the Referees on cereals to the Imperial Institute was that it seemed possible that the injury to the barley happened to that which failed to get railed and shipped before the monsoon set in a d consequently was stored in the cultivators' pits and huts, the serious effect being due to the humidity and warmth of the rainy season followed by a subsequent drying before the barley reached England. It was thought that the grain situated close to the wall of the pit suffered whilst that in the centre escaped. Subsequent experiment, as we shall show, demonstrates the effect to be due to the humidity, but there are other points of interest not suspected previously. The 10–20 per cent. that fails to germinate though is probably not due to its being the amount that is situated on the outside of the store. Observation makes us think that it is very doubtful whether any portion of the exported barley has ever been stored in any efficient way in the grain dealer's storehouse. The methods usually employed afford little or no protection from atmospheric conditions. The cultivator as a rule stores only the grain required for food and seed purposes and sells off his surplus stock at harvest time.

The small quantities of grain retained by the cultivators for seed and domestic use are usually stored in mud urns. In North-East India the cultivator's seed rate for barley as for many other crops is known to be high.

The reason is obvious. The whole subject of the germinating value of the seed usually sown by cultivators for their crops is worth further study.

A sample of barley was taken in June before the rains set in, and from this a number of small cotton bags were lightly filled with some 1,000 kernels each. Some of these bags were stored in a closed large dessicator, beneath the perforated zinc floor of which was about a pound of anhydrous calcium chloride. By this means the influence of the weather was removed and the seed kept until its regular germinating season. These bags of grain simply served as a control. They were used during barley-sowing season when a check experiment was deemed necessary. The germination of our barley was found to be uniformly high, samples from this dessicator often showing 99 per cent. and never below 96 per cent. germination. Others of these bags of grain were exposed for various intervals of time to atmospheres containing different amounts of water vapour. At the termination of these exposures the bags were transferred to a second large dessicator containing calcium chloride and remained there until barley-sowing season in November. At this season the germination of the barley subjected to various degrees of moist atmosphere for various durations of time was tested in each case.

The experimental method was as follows. In order to obtain atmospheres containing different amounts of moisture a number of small dessicators of approximately uniform size were taken. Into successive dessicators were put 200 c.c. of successively stronger solutions of sulphuric acid. (The sulphuric acid used was an ordinary commercial sample. The same sample of acid was used throughout the experiment. Its exact degree of strength and purity was unimportant as the technique of the experiment will show.) A start was made with pure water in small dessicator No. 1, and 2 per cent. sulphuric acid in No. 2, 4 per cent. in No. 3 and so on; there being an increment of 2 per cent. acid in the solution in each succeeding dessicator. Upon the perforated floors of the dessicators, over the acid, the small bags of barley were placed. The glass top of the dessicator was then hermetically sealed by means of a lute of resin cerate. After an interval of one week one bag was removed from each small dessicator. These bags were marked so as to show the strength of acid and duration to which they had been exposed. They were then transferred to a large storage dessicator in the bottom of which was a quantity of anhydrous calcium chloride. From this dessicator the bags were taken out as fast as they could be dealt with and the germination of the grains in the various bags tested. After a further interval of a week a second bag of barley was removed from each small dessicator, labelled, and transferred to the large dessicator to await its turn for a germination experiment of its contents.

This removal of bags from the small dessicators continued at weekly intervals. The germination tests were carried out as follows. The method is the one recommended by Schönfeld in *Wochensch Brau*, 1902, **19**, 768. A wooden stand containing a line of small glass funnels was fitted up. In the apex of each funnel a small plug of glass wool was placed. A short length of india-rubber tubing provided with a pinch cock was attached to the stem of each funnel. The barley was placed on the glass wool and then flooded with water for about five hours. The water was then run off by opening the pinch cock and the barley left alone for some 18–19 hours. At the end of this time the barley was again flooded for a second period of five hours. Two floodings were sufficient to start germination, and, with but few exceptions, all those grains that would germinate did so by the third day, very few lingered until the fourth, on which day the germinated grains were counted. The funnels were kept covered during the experiment with clock glasses. Observations of the maximum and minimum temperatures of the laboratory were made daily. The percentages of germinating grains are given in the table below. A set of estimations of the amounts of water vapour contained in samples of air exposed to solutions of sulphuric acid of the strengths used was then made. This was carried out in the following manner :—

A series of four small wash bottles was fitted up and into each was put a quantity of sulphuric acid of the percentage under consideration. The intake tube of one bottle was connected with the exit tube of the bottle before it, and the intake tube dipped beneath the surface of the acid in its bottle. Air was drawn slowly through this series of four bottles containing the sulphuric acid. Connected to the fourth bottle was a U tube containing calcium chloride. This calcium chloride tube was in its turn connected to a second one, and this again to a third calcium chloride tube which was followed by an empty U tube. Through all these tubes and bottles a measured quantity of air was drawn by means of an aspirator of 20,000 c.c. capacity. The air was drawn over very slowly, the whole 20,000 c.c. taking some five hours. The two calcium chloride tubes next the bottles containing the acid were weighed before and after the experiment. The third calcium chloride and the empty U tube also were simply to catch any water vapour passing back from the aspirator; they were not weighed. By this means we were able to estimate the number of grams of water vapour per litre contained in air over each particular percentage sample of sulphuric acid used. The following table gives the results :—

TABLE III.

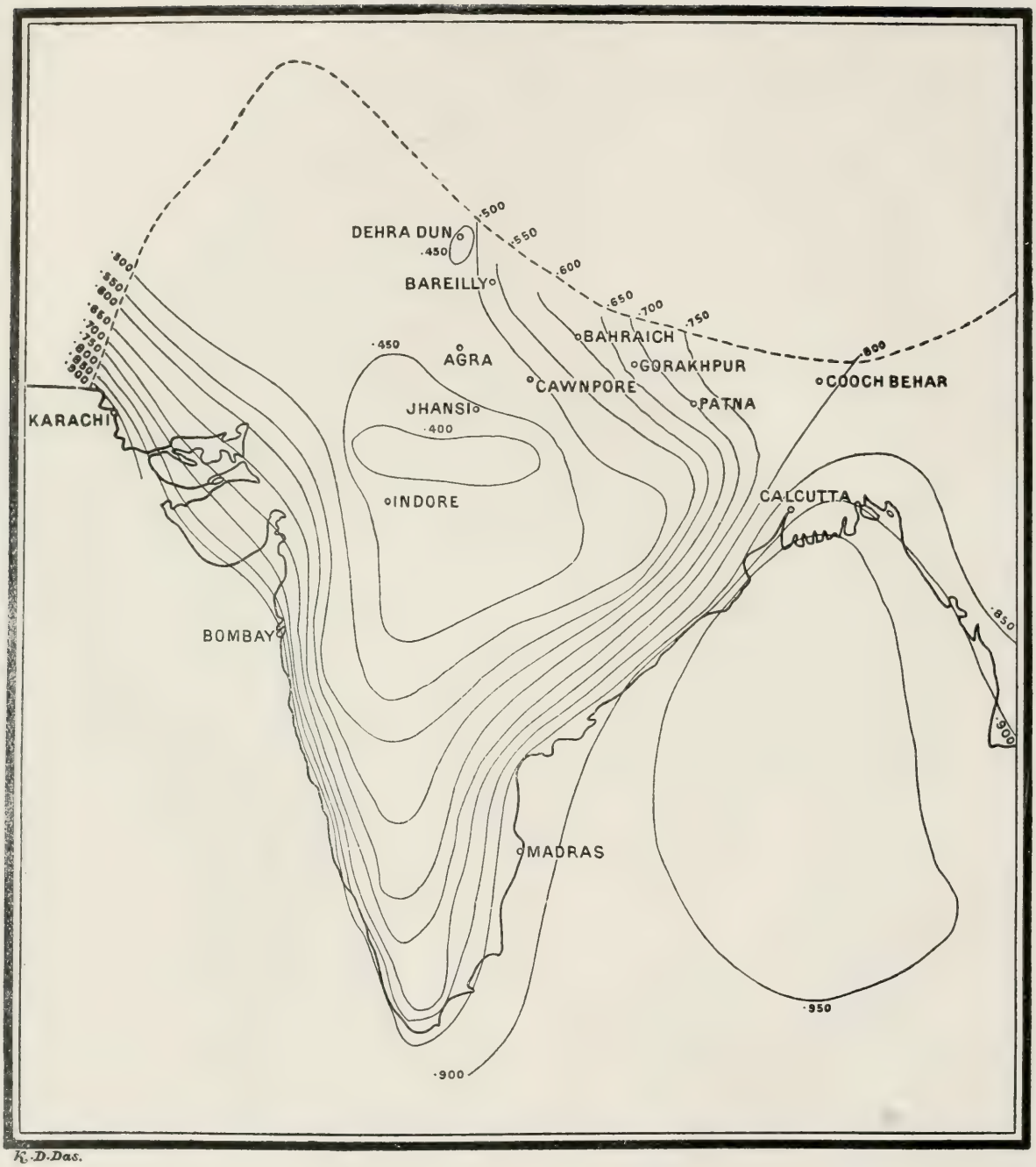
Germination tests with barley.

The germination tests were commenced on the 10th November and during the experiments the laboratory temperature at 8 A.M. was a maximum of 28°C. and a minimum of 18°C.

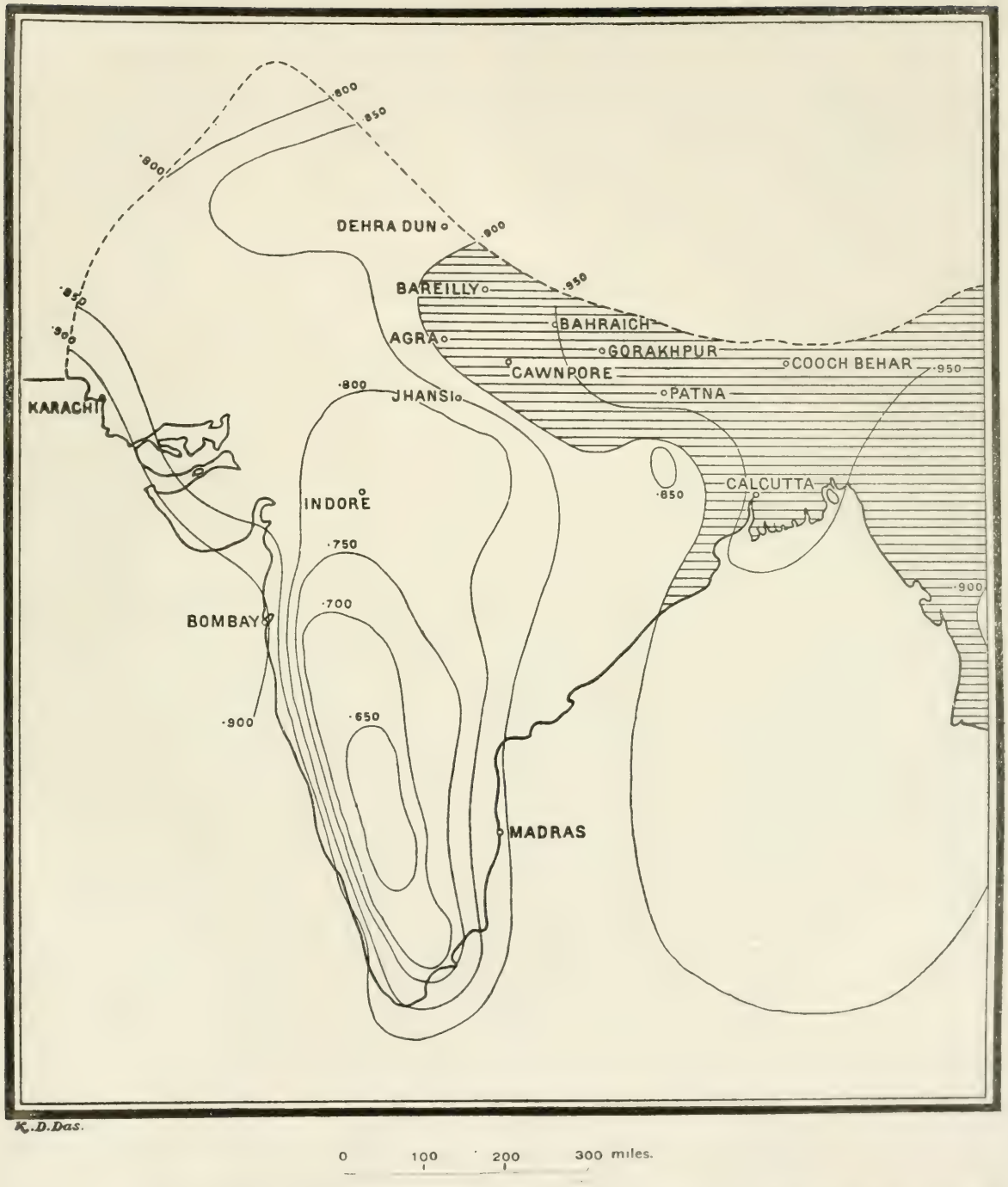
Percentage of H_2SO_4 used	Grm. water vapour per litre contained in air over this percentage of H_2SO_4 (as estimated by us)	T. of laboratory in which column 2 was estimated	Vapour pressure in inches of column 2 figures	Percentage of germinating grains after exposures of different durations													
				1 week	2 weeks	3 weeks	4 weeks	5 weeks	6 weeks	7 weeks	8 weeks	9 weeks	10 weeks	11 weeks	12 weeks	13 weeks	14 weeks
		°C.															
0 (*i.e.*, water)	*0·0307	31	1·3″	97·2	98·8	96·6	91·3	86·9	87·1	88·7	15·0	4·3	2·0	0·1	0	..	..
2	0·0264	23	1·1″	99·1	98·7	97·1	94·4	91 6	84·6	79·4	60·3	49·3	27·2	7·2	0	..	..
4	0·0233	30	0·96″	96·6	98·6	98·7	87·5	83·6	85·8	75·1	63·5	49·1	33·5	22·8	8·4	0	..
6	0·0223	30	0·92″	97·2	98·3	98·4	96·3	96·3	98·3	78·5	55·5	71·8	43·6	33·7	9·7	2·9	0
8	0·0216	30·5	0·89″	99·0	96·7	99·0	84·2	97·5	95·6	95·3	90·3	86·3	86·5	78·7	74·8	70·2	76·5
10	0·0213	30·5	0·87″	97·6	98·4	99·3	97·8	98·5	96·6	98·3	96·0	96·5	97·2	94·2	93·7	95·0	96·3
12	0·0199	30·5	0·82″	98·5	98·5	98·6	97·0	98·8	98·7	98·4	97·2	96·2	98·2	96·9	98·7	98·3	98·5

*This is the figure obtained by us. 0·0300 grm. is the weight of water vapour in 1 litre of saturated air at 760 mm. pressure and 30°C. By comparison with our figure an estimate can be formed as to the experimental error in our method.

The vapour pressure, p, in inches given in column 4, is found by the formula $p = W \times 37{\cdot}5 \times \frac{T+273}{273}$ where W=no. of grams of vapour in a litre of air. T=temperature of air in °C. and where air is at sea level under standard pressure of 29·92 inches.



May. Mean daily aqueous vapour pressure. Taking 0·900" aqueous vapour as the danger line for barley, it will be seen that at this season there is hardly any inland danger zone.



July. Mean daily aqueous vapour pressure. The shaded area represents the inland danger zone for barley. This persists somewhat similarly for some 12 to 14 weeks in the year.

From Table III given above it will be seen that a vapour pressure of 0·87″ (0·0213 grm. water vapour per litre of air) may be taken as the safest maximum to which Indian barley intended for germination may be exposed. Exposure to this amount of humidity for fourteen weeks has no deleterious effect. Exposure to greater amounts of humidity than this is serious. A vapour pressure of 0·89″ (=0·0216 grm. water per litre of air) after fourteen weeks or less reduces the germination by roughly some 25 per cent. and greater humidity than this totally destroys germinating power in fourteen weeks or less.

Comparisons between Table III and the maps showing the aqueous vapour pressures inland for the months of May and July are instructive. A series of these maps for each month of the year is to be found in the "Climatological Atlas of India." For fuller details a reference to them may be made. In short it may be said that conditions in June are intermediate between May and July and that July conditions represent somewhat those of August and September. October to April rarely shows vapour pressures above 0·85″ anywhere, not even on the seaboard. After May barley in North-Eastern India is to be regarded as having been subjected to atmospheric conditions that have a deleterious effect upon its germination. Unless extraordinary storage precautions be taken barley in this region during the period of the monsoon will have its germination reduced by anything up to some 25 per cent. Thus we see where and why the cultivator's seed rate is high. Barley required for malting purposes (or any other use involving its germination) should not be that exported from Calcutta after May. Bengal, Bihar and Orissa, and Oudh produce the barley exported from Calcutta. Its germination could, if necessary, be fully protected by transporting it from the danger zone toward Karachi or Bombay before, say, the end of June. This would involve some extra cost for increased railway transport. It should not be stored on the Western seaboard area. Barley in North-West and Central India has its germination unimpaired throughout the year and if exported from Bombay or Karachi, and not delayed long in the seaboard area, will not have suffered from the effects of harmful atmospheric conditions. It might be supposed that humidity conditions over the ocean which the grain would encounter during seaborne transport to Europe are above the safety maximum. They may be, but on a normal voyage they are not likely to last sufficiently long to have a serious effect.

In conclusion, I wish to acknowledge the assistance received from Mr. A. Wilson, of the Indian Agricultural Service ; The Director of Statistics, India ; and The Director-General of Observatories, Indian Meteorological Department.